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# THE HABITS, LIFE HISTORY, AND STRUCTURE OF A BLOOD-SUCKING MUSCID LARVA (*PROTOCALLIPHORA AZUREA*)*

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While studying the blood parasites *Halteridium* and *Proteosoma,* and the *Filaria* of the common crow (*Corvus americana*), my attention was attracted by an external parasite of some young nestlings which were brought into the laboratory. Observations on this parasite, which proved to be the larva of *Protocalliphora azurea* (Fall.), form the basis of this paper. The parasite is the immature form of one of the so-called "blue-bottle" or flesh-flies, whose larvae are generally regarded as useful scavengers. More careful observations on the life-histories of many species, however, have shown that they may be, and often are, parasites of the higher animals.

The work was undertaken with the double purpose of seeking further knowledge of this parasitic habit of certain Sarcophagidae and of increasing the knowledge of the systematic characters in the group. It was carried on in the Entomological Laboratory of Cornell University under the direction of Prof. Wm. A. Riley, to whom I am gratefully indebted for continued suggestion and aid. I am also indebted to Prof. O. A. Johannsen, whose aid in the systematic part has been invaluable.

## HABITS OF THE LARVA

On June 13, 1914, two young crows were brought to me. They were from the same nest and from comparison with others which I had reared, I judged them to be about five weeks old. They were put in a cage separate from my other crows, and seemed quite normal, save for fright. Three days later, however, one of them died and a post-mortem examination was made. Crawling among the feathers I discovered several larvae which looked in general like those of the Muscidae. They were from four to nine millimeters in length and were wriggling actively among the feathers, as if accustomed to this habitat. None were seen actually attached to the bird and feeding. The surface of their bodies was not a white or creamy color, as are the bodies of most of the blow-fly larvae, but was more the color of dirt. The contents of the alimentary canal showed through the skin dull-red, giving the whole larva a brownish-red appearance. Eleven

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specimens were found on this bird. Most of them were among the feathers of the abdomen and were quite dry, but three were found in one ear cavity and were moist. The ventral part of the body of the crow had a number of small scab-like spots on it where the larvae had been feeding.

From the color of the alimentary canal of the larvae, I judged them to be blood-sucking, although this habit is not common in the larvae of this family. To test this I cut one in half and smeared the contents of the alimentary canal on a slide. Examination with the microscope proved conclusively that the alimentary canal was full of corpuscles of crow's blood. The crow, on further examination, proved to have died of malarial fever and there were enormous quantities of *Halteridium* in its erythrocytes. On discovering this I returned to the study of the blood from the larva's intestine, using an oil immersion lens, and thinking to find out whether the malarial parasites might become sexually mature here and give off the motile microgametes, as they do in the stomach of the Anopheles mosquito. I found no indication that this occurred.

Afterwards the floor of the cage under the straw was examined, and in the dirt I found forty or fifty more of the larvae, of various sizes and ages, crawling vigorously. All of them had more or less vertebrate blood in them, some of the larger ones having less than the smaller ones. From this I infer that the larvae are intermittent feeders, probably spending most of their time in nature in the dirt and more compact part of the bottom of the nest. The same day while feeding and holding in my hands the other crow from this nest, I observed one of the larvae clinging by its anterior end to the tibio-femoral joint of the crow's leg. Before I could examine it closer, the bird began to struggle and the larva released its hold; so I could not see the process of ingesting blood. Subsequently I placed larvae on my arm and in the hairs under the armpits, but they seemed very sensitive to handling and would not settle down to feeding. I made a number of attempts to rear the larvae on fresh and putrifying meat, flesh and liver of the crow, and beef. All of these experiments resulted negatively, except that one larva lived to pupate and died in this stage.

On the same day the larvae were found, I secured two young chicks of about the same development and allowed two maggots to crawl into each ear cavity, making eight larvae in all. They seemed to irritate the birds, and soon the latter began to shake their heads and scratch their ears. In this way one of them succeeded in digging the larvae out of one ear, but the other six remained well in. I also tried to make the larvae "take hold" of the skin under the feathers of these birds, but they dropped off as soon as the chick shook itself.

Two days later one of the chicks died but post-mortem showed the cause of death to be a tumor in the left cerebral hemisphere, not connected in any way with the experiment. One larva was found in the right ear of this chick, the only one left of the four put on it, and this one died soon after without reaching maturity.

The fourth day after putting in the larvae, I examined the remaining bird's ears with a soft probe. Both cavities were free of larvae. The chicks had been kept in a case with a false wire bottom, two inches below which was the true bottom covered with half an inch of soil so that if the larvae emerged they would not be eaten by the chick but might pupate. After finding that the larvae were not in the ears, the soil of the cage was gone over carefully but no larvae or pupae were found.

Some of the larvae, especially the larger ones, were left on the floor of the crow's cage and the nest was not cleaned up. Eight days later ten puparia were found under a large piece of paper on the floor of the cage. As the cages were screened from other flies, these must have come from the same larvae. Furthermore, they were identical with the one larva which did pupate in the laboratory. The pupae were in quite a dry place, away from the wet fecal matter of the cage. They were removed to a stender jar and kept moist with a wet filter paper hung in the top of the jar.

In the hope of learning more of the habits and distribution of these larvae, I began visiting birds' nests in the vicinity of Ithaca. I went first to the crow's nest from which the infected birds were taken, just one week after their removal. Crows' nests are from one and a half to two feet in diameter; six inches to a foot deep, and contain a large quantity of rich moist earth below the grass which lines the nest. They are seldom used more than one year. I examined the debris and earth of this nest carefully but found neither larvae nor pupae of the form I was seeking. Subsequently I examined three other crows' nests but found none of the parasites. I have also examined seven swallows' nests (*Hirundo erythrogaster*), all but one of which still had young in it. These also had no larvae. In a house-wren's nest (*Troglodytes aedon*) in a hollow stump, one anthomyid larva was found, but no *Protocalliphora azurea*. Two sparrows' nests (*Passer domesticus*) yielded negative results, as did the examination of one robin's nest (*Merula migratoria*).

An instance of what was very probably an infection of *Protocalliphora* was reported to me shortly after this by Mr. W. D. Funkhouser. While walking in the woods he found a nestling chipping sparrow (*Spizella socialis*) lying in the path. The bird was quite old, almost fully feathered and he could not think what ailed it. As he

held it in his hand a small dipterous larva crawled out from beneath the skin of the neck back of the ear. It was about a quarter of an inch long, and seemed to him of a whitish color. Mr. Funkhouser had no place to keep the larva so he did not save it. He brought the bird home but it died after a few hours and was not examined further.

At the time these observations were made I had no idea that similar ones had been recorded before. They immediately suggested, however, the case of the Congo floor maggot, *Auchmeromyia luteola* (Fabr.), which is also blood-sucking in its habit. The larva of this muscid, which is quite widely distributed in Africa, especially in the Congo region, parasitizes the natives by piercing the skin and sucking the blood. From the account of its habits given by Dutton, Todd, and Christy it appears to be an intermittent feeder, just as *Protocalliphora,* living in the soil on the floor of the huts and feeding at night when the natives are sleeping on the ground. Roubaud (1913) mentions several species of the genus *Choeromyia* which occur in the Soudan and Timbuctoo regions, whose larvae have similar habits, and suck the blood of aard-varks and wart-hogs. But I was not aware that the occurrence of a blood-sucking larva on birds had been reported until the adult flies had emerged. Then on identifying them, I found the following accounts of the larval habits of this species.

The most careful discussion is given by Leon Dufour (1846). In the spring of 1845 he accidentally discovered some larvae on some young swallows in a wooden box-nest in his garden. He found many more of the larvae and some pupae on the floor of the box and on the ground beneath, and reared the adults. He noticed the "short and fine downy velvet" of the integument, which gave it a grayish appearance, and the "footless and headless" character, and soon guessed the larva to be a parasite. He dissected several specimens and found the alimentary canal full of a dark-red fluid which looked like blood, so he inferred that they were blood-sucking in habit. But he did not definitely know this and in fact was not completely assured of it, because he thought parasitism by such a large number of maggots, would almost necessarily affect the health of the young birds; but this was not the case, as the latter matured and flew. The same old pair of swallows had a second brood in mid-August which were less numerously parasitized than the first litter.

Scheffer is reported by Rossi in 1848 to have taken the larvae of this species from a brood of larks. The larks died. Kirsch in 1867 describes what are apparently the larvae of *P. azurea* crawling out of the neck of young sparrows. He did not rear the adults. Nowicki in 1867 also took the larvae from young sparrows.

Brauer in 1867 took *Protocalliphora azurea* "subcutaneously" from nestlings of a swallow (*Hirundo rustica*) and *P. chrysorrhea* (Meig.), a closely related species from *Hirundo riparia*. According to Strobl in 1894 Schieferer took from the grass of a raven's nest ten specimens of *P. chrysorrhea,* both male and female.

In this country Henshaw (1908) notes the occurrence of *Protocalliphora chrysorrhea* on two successive broods of blue birds in Massachusetts. The infestation was so severe that of eight nestlings only one survived.

Du Buysson (1912) attempted to verify Dufour's observations. He found the larvae on swallows June third and obtained pupae, but these had failed to emerge on August 23. He thought that they were resting and would emerge the following spring, but they were probably dead. Rodhain (1914:213) reports finding the larvae and pupae of a muscid in the nests of the grey-headed sparrow (*Passer griseus*) at Bambili in the Congo. He found that these larvae contained avian blood. They were reared but the adult fly had not been determined. It is not, he says, a species of Cheiromyia [misspelling for Choeromyia?].

## CONCLUSIONS REGARDING THE HABITS OF THE LARVAE

1. Dufour's suggestion that the larvae sucked the blood of the host is definitely proved by my microscopic examination of the contents of the alimentary canal.

2. The larvae play no part in the transmission of the malarial parasite.

3. They are intermittent feeders. This is based on the following facts: a) Many more larvae were found on the floor than were actually on the birds. b) They seemed perfectly at home there, and moved about in the refuse and on the dry floor quite naturally. c) They were very excitable, and would not settle down or take hold on a bird which struggled and were easily shaken off by the chick. d) One found feeding on a crow which was quiet, immediately released its hold and dropped to the floor when the latter became active.

4. The larvae prefer rather dry places to moist ones and are therefore not accustomed to living in decomposing or fecal material.

5. The larvae do not feed on solid flesh, either fresh or decayed, although they may (Kirsch, Brauer and Funkhouser's observations) bore in living tissues.

From these conclusions it is evident that the species *Protocalliphora azurea* is a blood-sucking parasite on nestling birds, that this habit is normal, not accidental, and that its effect on the host varies, in some instances (Schiffer, Henshaw) being fatal, in other cases (Dufour, my own observations) apparently not affecting the birds' health at all.

The parasitic habit of this species shows a further step in specialization among the larvae of the Calliphorinae. Some members of this group, as flies of the genus *Pycnosoma,* live only on the rich decomposing organic excrement from man and other animals and are therefore quite free-living. The next step may be represented by the species of blow-flies, Lucilia, Calliphora, Homalomyia, etc., which usually live in dead and decaying animal flesh. The tendency towards the parasitic habit is shown, however, in their accidental or facultative parasitism of the higher animals when they find an open sore or decomposing flesh near the living tissue. In such cases they cause myiasis just as do the more usual skin maggots (Chrysomyia, Cordylobia, etc.). The members of the genus Chrysomyia carry this habit further and usually develop in living flesh, wherever there is an abrasion of the skin or bleeding surface, though they can live in decomposing matter. The genus Cordylobia contains the "Thumbu fly" of Africa, *C. anthropophaga,* which normally gains access to and settles down under the skin, showing that it has become exclusively parasitic. Parasites which live on the cutaneous and connective tissues, however, have scarcely attained to as high a degree of perfection in the parasitic habit as those which live on the blood, the most nutrient tissue of their host. The extreme of parasitism in this group occurs, then, in the larvae of those genera which always puncture the skin and suck the blood of their host. Of these there are but three genera known, the two in tropical Africa, Auchmeromyia and Choeromyia, and the genus Protocalliphora which has been found in Europe and North America. The length of life of the larva is probably between fourteen and twenty days.

## STRUCTURE OF THE LARVA

Weismann in 1864 believed there were three larval stages or instars in the blow-fly (Calliphora). Hewitt (1908) has shown that there are three in the development of *Musca domestica,* and this is generally thought to be the number in the Muscidae. I presume that there are three larval stages in *Protocalliphora azurea,* although I have found larvae in the last two stages only. The structure of the larva is essentially the same as that described for the Muscidae and is best described by reference to the accompanying drawings (Figs. 1 to 5).

The larvae are 6.0 to 7.0 mm. in length in the second instar and but little larger after the moulting. I find that there are but twelve segments in the larva. The first of these, called by Henneguy the "pseudo-cephalon," corresponds to the head of the more generalized larvae, although in the Muscidae it is very much degenerated. In *Protocalliphora* it is small, membranous, and not covered with spines, as the following segments are. It differs from other larvae of the

muscid type in that it is completely retractile, the entire segment being reflected, as Dufour says, "like turning a glove outside in," when the larva is sucking. When extended it is divided on the ventral side by the pharyngeal cavity from the dorsal edge of which the two mandibular hooks project. On the dorsal aspect the two halves of the segment are united over the hooks, and the lateral portions project cephalodorsad in two pairs of small tubercles.

The mandibular hooks (Fig. 2) are the distal sclerites of a large, chitinized structure which extends back in the body as far as the second or third segment, and which is the chief prehensile organ of the larva. It is made up of several sclerites and is termed by Hewitt in the housefly the "cephalopharyngeal skeleton." The mandibular sclerites are two in number in Protocalliphora, as in Calliphora (Lowne) but in

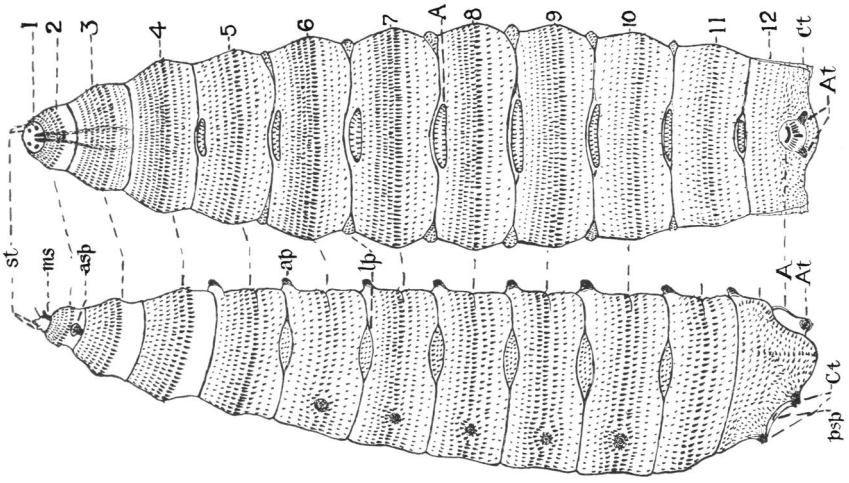


Fig. 1.—Ventral aspect of second and lateral of third instar. X 10. (*A*) anus; (*ap*) abdominal pad; (*asp*) anterior spiracle; (*At*) Anal tubercles; (*Ct*) caudal tubercles; (*lp*) lateral pad; (*ms*) mandibular sclerite; (*psp*) posterior spiracle; (*st*) sensory tubercles.

*Musca domestica* there is but a single median sclerite according to Hewitt. The remaining segments of the body present the peculiarity of being more or less covered with rows of sharp-pointed, hard, chitinous spines or scales. This spiny coat gives the larva the characteristic dirty brown color and velvety look previously mentioned, instead of the smooth creamy-white appearance which most muscid larvae have. In the second instar the spines are minute and some distance apart but after the next moult they are much larger and more closely packed and form a veritable coat-of-mail.

I believe that the second, third, and fourth segments correspond to the pro-, meso-, and meta-thorax, respectively, agreeing with the inter-

pretation of Weismann, Brauer and Lowne. There is no evidence on any of my specimens of a constriction dividing the second segment into two, as Hewitt found in the house-fly, and the arrangement of spines may be taken as an additional indication that this is but a single segment.

Extending cephalad from under the anterior margin of the third segment on the two lateral sides of the larva are the anterior spiracles

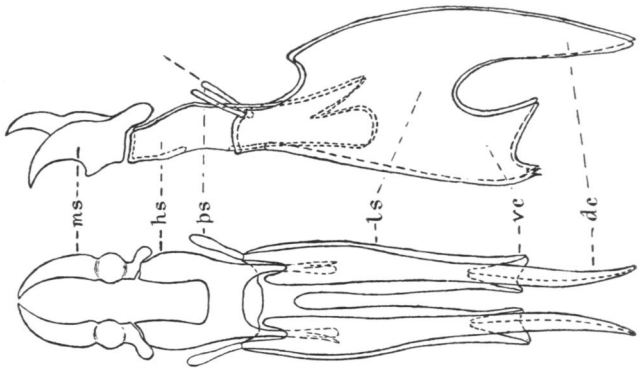


Fig. 2.—Cephalo-pharyngeal skeleton in dorsal and lateral aspects. X 75. (*dc*) dorsal cornu; (*hs*) hypostomal sclerite; (*ls*) lateral sclerite; (*ps*) parastomalsclerite; (*vc*) ventral cornu.

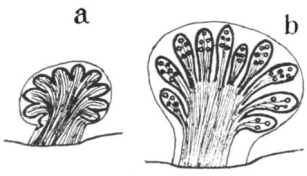


Fig. 3

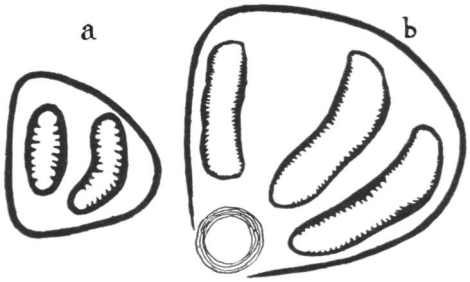


Fig. 4

Fig. 3.—Anterior spiracles of larva; (*a*) second instar; (*b*) third instar. X 125.

Fig. 4.—Posterior spiracles of larva; (*a*) second instar, X 125; (*b*) third instar, X 250.

(Fig. 3). They are small and probably not functional in the second instar, but in the third stage present ten well-developed ostioles or papillae, covered by a delicate membrane. Each ostiole has several small pores in it which apparently are functional.

The fifth to the twelfth segments correspond to the abdomen. Each segment has on its ventral side, near its cephalic border, a transversely

elongate, oval, elevated pad. These "locomotory pads" (Hewitt) are homologous to the abdominal prolegs of lepidopterous larvae. In addition on the sides of the body there is between each of the segments except the last two, a small but constant spindle-shaped lateral piece (Fig. 1).

The twelfth segment is considerably modified by the posterior spiracles and the anus; its form and the arrangement of structures may be readily made out by reference to the figures. The posterior spiracles, two in number, lie in the depressed quadrilateral area of the segment which looks dorso-caudad. There are two large elongate ostioles, surrounded by a chitinous ring, in each spiracle during the second instar but there are three ostioles in the third (Fig. 4).

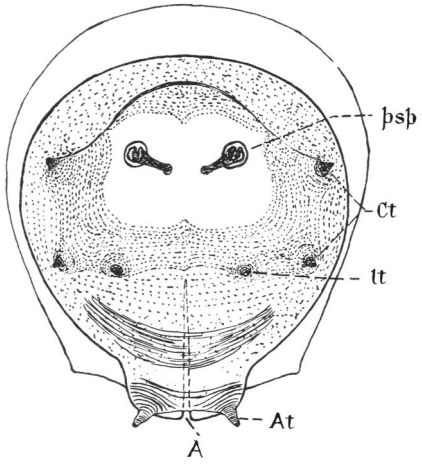


Fig. 5.—Caudal aspect of larva; second instar. X 20. (*lt*) lesser tubercle.

## THE PUPA

The larvae when ready to transform, apparently leave the more occupied parts of the nest in the vicinity of their food-supply and seek a dry, quiet portion, usually at the bottom. They seem to transform normally in such places, instead of in the earth as most of the Sarcophagidae do.

The adult emerges from the frontal end of the puparium as in all of the Cyclorrhapha. First a longitudinal slit is made in a frontal plane extending caudad from the larval mouth-opening in a line which passes just ventrad of the anterior spiracles. When this slit has been extended as far as the fifth segment, the dorso-ventral pressure on the two portions is so great that a circular splitting commences. This begins at the lateral faces of the fifth segment and extends dorsad

and ventrad far enough to allow the two anterior portions to spread apart as the fly emerges. They then spring back into place and usually remain attached, each portion connected to the rest of the puparium by a small part of the dorsal and of the ventral walls, respectively. Dufour noticed the longitudinal split on Protocalliphora, but thought that it occurred secondarily to the circular splitting.

Whether this manner of splitting occurs in many of the Cyclorrhapha or not is difficult to say. Most writers remark that the flies emerge by splitting off a circular "cap" at the anterior end. Hewitt however, in a careful study of the house-fly states that "the fly pushes off the anterior end in dorsal and ventral portions . . ." "The splitting of the anterior end of the pupal case is quite regular, a circular split is formed in a line below, i. e., ventral to the remains of the anterior spiracular processes of the larva."

Professor Johannsen states that in all the individuals of the Calypterae whose puparia he has noticed, including Sarcophaga, Lucilia, Calliphora, and Musca, the "cap" is always split in a diametric line as well as circumferentially.

The size of the puparium varies from 6.0 to 9.0 mm. in length, from 2.2 to 3.4 mm. in width (laterad) and from 2.1 to 3.2 mm. in depth (dorso-ventrad). Its general shape is that of a typical muscid. However, the puparium of *azurea* is not shiny, like that of Musca, Muscina, Lucilia, etc., but has a dull, blackish, and soft or velvety appearance. It is light brown, slightly reddish in color when held towards the light, but when looked at by reflected light it has a very dark or black color. This dull dark appearance is caused by the rows of spines of the larval skin, which have already been described. The length of the pupal life in my experiments was about ten days.

## THE ADULT

The adults were kept in a good-sized breeding-cage with moist earth and some pieces of meat, both fresh and putrid, and were fed on crackers and milk, which they ate readily. They were not attracted to the flesh at any time, as other blow-flies are, and preferred the crackers and milk for food. It is evident, therefore, that the adults as well as the larvae are quite different in their habit from the commoner Calliphorinae.

Both *Protocalliphora azurea* and *P. chrysorrhea,* which is closely related to it in structure and habits, are recorded by collectors and dipterologists as "rare" or "very rare," and specimens are found only in the larger museums and collections. I am inclined to think, however, that they are not so rare as is generally supposed, but that the adults are peculiar in their habits, flight, etc., and for this reason are rarely

taken. From the habits of the larvae we would scarcely expect to find the adults around dung-heaps, decaying flesh, and similar places where the Calliphorinae are usually sought for. Few collectors, I imagine, have taken insects very often from the zone of air from fifty to one hundred feet above the ground, in the woods; yet from the habits of the larvae, this is where we would naturally expect that the adults would occur. And the contents of birds' nests have not been studied to any appreciable extent from an entomological point of view. It seems probable, therefore, that they may be fairly common in spite of the few times they have been taken.

*Protocalliphora azurea* has been reported from two or three places in France and a few places in Germany and Italy, and Walker reports one specimen in the British museum collection. In North America Hough declares the species "very rare." Mr. C. W. Johnson has kindly noted for me, however, that there are three specimens in the collection of the Boston Society of Natural History, all taken in New England within the past few years.

In its parasitism the species is not limited to a single host but it seems to occur more frequently among the birds which build more protected and stable nests, as in boxes of earth, etc.

The species was first described by Fallen in 1816 under the name *Musca azurea*. Meigen listed it under the same name in Systematische Beschreibung. In 1845 Dufour, on the authority of Macquart, gave the species which he had reared the name *Lucilia dispar*. Schiner in Fauna Austriaca described Fallen's species as *Calliphora azurea* and remarked that after comparing Dufour's specimens he determined that *Lucilia dispar* is a synonym of *Calliphora azurea*. Rondani classified the species *azurea* as belonging to the genus Pollenia. Finally, Hough in dividing up the North American genera of Calliphorinae created a new genus, Protocalliphora, and takes as the type species the one under present consideration, the *Musca azurea* of Fallen. Two years later Hendel, unaware of Hough's work, recognized the same differences and erected the genus Avihospita. The latter therefore falls as a direct synonym of Protocalliphora.

Since the species has not been taken often, and since no very detailed description of the adult is available, I offer the following additions to the specific characters which other authors have given size, 7.6 to 10.0 mm.; head, in the female, twice as broad as long, and as broad as the thorax and abdomen (from 2.5 to 3.0 mm.). The second segment of antennae is reddish-yellow with large black hairs; third segment, including the arista, black. (Hough states that the antennae are black, without noting that the second segment is always brown or yellow). The median half of front, from vertex to antennary

fossa, is clothed with soft short black hairs, giving it a downy appearance; each lateral quarter of front is scaled with comparatively large white scales. The cheeks (bucca) are metallic blue, with a rather sparse, coarse black beard; palpi are moderate-long, reaching to the oral margin, and reddish-yellow in color throughout (sometimes quite a dark brown); they are clothed with black hairs which are quite long towards the apex.

The chaetotaxy of the head is as follows; ocellar pair of macrochaetae, mid-way in each ventral side of the ocellar triangle present, besides several microchaetae within the triangle; two pairs of verticals present, the inner pair larger, convergent, and decussating near the tips, the outer pair divergent; in front of, and between the verticals, is a pre-vertical bristle. There are two pairs of fronto-orbitals. The

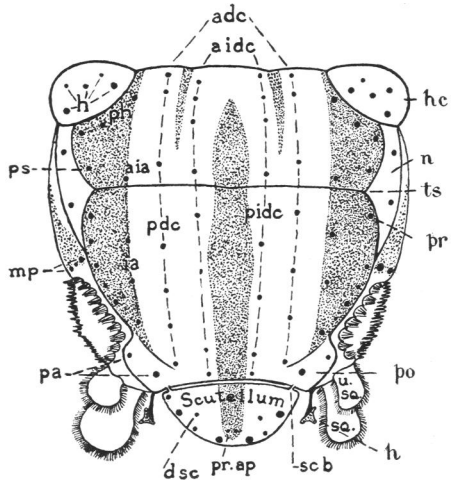


Fig. 6.—Dorsum of thorax in adult. X 10. (*adc*) anterior dorso-centrals; (*aidc*) anterior inner dorso centrals; (*aia*) anterior intra alar; (*dsc*) dorsal scutellar; (*h*) humerals; (*ia*) intra alars; (*pdc*) posterior dorso centrals; (*pidc*) posterior inner dorso centrals; (*ph*) post humerals; (*pa*) postalars; (*pr ap*) pre-apical; (*ps*) pre-sutral; (*sa*) supra alars; (*sc b*) scutellar bridge; (*sq*) lower squama-squamula thoracalis; (*u sq*) upper squama-squamula alaris.

row of frontal bristles is fairly constant and well-developed, usually nine, sometimes eight or ten. I have no specimens of the male.

The thorax is a lustrous metallic steel blue color, throughout. On the dorsum, however, this blue color is overlaid by a fine whitish bloom, which covers most of the mesonotum, except in definite areas where the blue shows through. These areas are indicated on the drawing of the thorax (Fig. 6). The squamae are prominent, whitish-colored, and covered with a very fine down on both surfaces, with a fringe of longer hairs around the edge. The legs are black; the halteres white. The

wings when at rest are folded over the abdomen, their outer (anterior) margins parallel to the body. The wing venation is very constant in the smallest details, and is as described in other works.

The position and numbers of the various macrochaetae which are constant on the thorax in this species may be seen from the accompanying drawings (Figs. 6, 7). They are as follows: on the dorsum, the anterior inner dorso-centrals (acrostichals), composed of four well-developed macrochaetae (*a idc,* in figures); the posterior inner dorso-centrals (*p idc*), also containing four bristles, each present in all the specimens I have examined, although they vary somewhat in size, and frequently in position (the second and third posteriors most often). This differs from Hough's observation that the posterior acrostichals vary in number or are poorly developed in *Protocalliphora.* The anterior dorso-central bristles (*a dc*) are three in number, the posterior

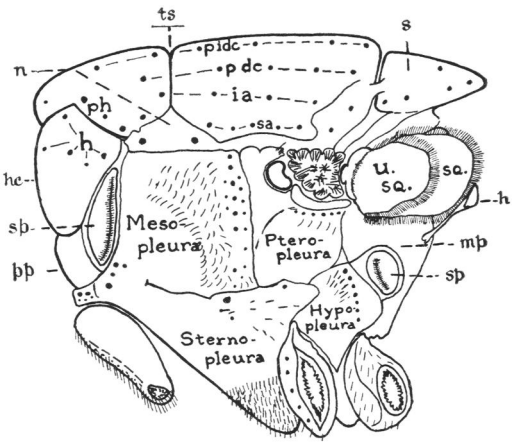


Fig. 7.—Lateral aspect of thorax in adult. X 10. (*h*) halteres; (*hc*) humeral callus; (*mp*) metapleura; (*n*) notopleur; (*po*) postalar callus; (*pp*) propleura; (*pr*) prealar callus; (*s*) scutellum; (*sp*) spiracle; (*ts*) transverse suture.

(*p dc*) four; the intra alars are three in number (*i a*). A single small anterior intra alar (*a ia*) is present, three to five supra alars (*sa*), and one presutural (*p s*). There are three posthumerals (*p h*), five humerals (*h*), and two well-developed post alars (*p a*). The scutellum has a peripheral row of bristles which varies in number from six to ten (three to five on each side); there is sometimes an odd number of them, due to the presence of a macrochaeta on one side without a mate on the opposite side. These bristles have each been given an individual name by Girschner, but since their development seems more or less irregular and inconstant, I simply call them the peripheral row. In addition to these I have found two pairs of bristles on the dorsal

surface of the scutellum. The dorsal scutellar pair (*d sc*) (so-called by Girschner), are not in line with the inner dorso-central row but laterad of it. The pre-apical scutellars (*pr ap*) are quite small, but are markedly different at the insertion from the microchaetae. Both pairs are present in all of my specimens.

Not having any male specimens of *Protocalliphora azurea,* nor any specimens of *P. chrysorrhea,* to examine, I can not tell whether this arrangement of bristles on the scutellum is a specific character or not. But I strongly suspect from the work of Girschner and from a comparative study of these bristles in Luciliar, Phormia and Calliphora, that it is a generic rather than a specific or sex character.

There are two macrochaetae on the notopleura; the mesopleurals are usually seven in a vertical row, the second from above sometimes rather undersized. In two cases there are eight, the extra one being in

TABLE OF MICROCHAETAE ON THE NOTOPLEURA OF PROTOCALLIPHORA AZUREA

| Specimen No. | Bristles Before the Posterior Macrochaeta | Bristles Behind the Posterior Macrochaeta |
|---|---|---|
| 1 L (left side) | 8 | 6 |
| R (right side) | 8 | 7 |
| 2 L | 8 | 5 |
| R | 8 | 4 |
| 3 L | 7 | 3 |
| R | 16 | 4 |
| 4 L | 10 | 5 |
| R | 8 | 4 |
| 5 L | 8 | 5 |
| R (destroyed) | .. | .. |
| 6 L | 7 | 3 |
| R | 5 | 3 |

the space before the last bristle. The pteropleura is quite bare save in the region under the wing-base, where there is a row of from four to six rather small macrochaetae. The hypopleural row is composed of seven well-developed and constant macrochaetae. On the dorsal margin of the sternopleura there are three bristles. The long microchaetae on the sides of the sternopleura gradually become more dense ventrad, and the individual hairs also become much thicker, until they must be called macrochaetae. They are too numerous to be readily counted. There are a number of macrochaetae on each coxa. Near the cephalic margin of the fused mesopleura and sternopleura are four macrochaetae, arranged as indicated in the figure. Two of them are much smaller than the other two. More cephalad still, between the propleura and the front coxa are two other bristles.

Since the work of Osten-Sacken the importance of chaetotaxy in the classification of certain groups of the Diptera has been well recognized, and it has been suggested that since setae occur in every form and size between the macrochaetae and the microchaetae, there must also be a very definite microchaetotaxy in the various genera and species. As a preliminary record on this point, I have counted the microchaetae on the notopleurae of each of my specimens.

Those anterior to the posterior macrochaetae are fairly constant in number, though there seems to be no very regular arrangement. There are usually eight, but sometimes six to ten. Those behind the posterior bristle gradually taper off to such minute hairs as are scarcely visible, and vary irregularly in number (from three to seven).

For comparison with other genera I have counted specimens of *Lucilia sericata* and *L. caesar,* of *Calliphora erythrocephala, C. viridescens,* and *C. vomitoria,* of *Protophormia terrae-novae,* and of *Phormia regina.* The exact number of microchaetae is not the same in all specimens of the different genera, nor on the same sides of the same specimen. Nevertheless there is in each genus a general range within which all members fall, and this is so constant that I am convinced that it is at least of generic significance. Thus, in Phormia the number ranges from thirteen to nineteen, the majority having sixteen; in Lucilia there are from fourteen to twenty-five, the majority having twenty plus; in Protophormia the range is from fifteen to thirty, the majority grouping around twenty-six; while in Calliphora there are a great many more, the number running from thirty to seventy-five, with the majority having a number in the vicinity of forty.

The abdomen has the typical muscid shape. It extends 3.5 to 4.0 mm. beyond the end of the scutellum, only four segments showing in the dorsal aspect. The color of the abdomen in the females is a metallic blue-green on the first three segments, the tip being a lighter golden green. It is slightly pollinose (less so than the thorax) so that in some aspects it has a whitish appearance. It is covered by rather long black microchaetae, which on the caudal margin of the last two segments become enlarged and thickened and are practically macrochaetae.

## SUMMARY

*Protocalliphora azurea,* a Muscid larva, occurs as a normal blood-sucking parasite of nesting birds, with fatal results in some cases. This represents the extreme specialization of these larvae towards parasitism; many intermediate stages are also represented in other members of the group.

The structure of the larva and of the pupa are described in detail, and also the habits and distribution of the adult. The anatomy of the adult is discussed with especial emphasis on the distribution of the bristles as this is very regular and of marked significance in taxonomy.

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